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HOW DAMAGING IS A MOUNTAIN PINE BEETLE INFESTATION?

A Case Study

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BACKGROUND

During the past two decades to the present, the mountain pine beetle has caused widespread killing of lodgepole pine in the Intermountain West. Although there is a long history of earlier outbreaks, the present one, for all practical purposes, can be said to have started in the early 1950's on the North Slope of the Uinta Mountain Range in northern Utah. As this infestation gained momentum during the late 1950's and early 1960's, other infestations developed, and by the mid-60's, several full-scale epidemics were in progress throughout most of the lodgepole pine type in northern Utah, western Wyoming, and southeastern Idaho.

Control projects were conducted annually, beginning in 1958 on the Wasatch National Forest, Utah, and ending in 1970 on the Targhee National Forest, Idaho. In the interim years, other projects were undertaken on the Ashley National Forest, Utah, and on the Teton National Forest and in the Grand Teton National Park, Wyoming. The purpose of these combined efforts was to reduce tree killing to the extent possible and to protect high value timber and recreation areas. They were, for the most part, destined to failure by a lack of understanding of lasting control effectiveness.

The overall effect of a "going" mountain pine beetle outbreak in lodgepole pine, whether to a forester, entomologist, or forest visitor, is most vivid and often times leaves a lasting impression. Standing on a vantage point and viewing the almost continuous canopy of an infested lodgepole stand at the height of the outbreak, all one sees is an expanse of red. In the aftermath of the outbreak, once the infestation drops to a low level and the dead trees finally shed their "colorful" foliage, the hue shifts from sorrel to grey, and the impression one gets then is a "ghost forest" rather than a "sea of red."

With these experiences, it is difficult to maintain objectivity as to the impact of the beetle on the forest once an infestation has peaked or run its course. Consequently, in many cases, emotion transcends fact and descriptive terms, such as destruction, decimation, and devastation, begin to creep into the vocabulary of well-meaning persons in their attempt at describing the dynamics of an infestation and its suspected impact. However, considering the circumstances, their past pessimism is certainly justified. First, many had witnessed one or more serious infestations from beginning to end, and were

expected to manage the final result; secondly, other than the work by Evenden and Gibson (1940), there was no definitive information available on stand impact; and finally, the remaining literature on the mountain pine beetle and its effects on the stand was anything but encouraging. Beal (1939), for example, stated "During outbreaks this insect attacks vigorous, healthy trees and frequently, as a result of its destructive work, extensive stands of pine timber are practically wiped out." Hopping and Mathers (1945), in describing an outbreak in lodgepole pine in one area in British Columbia, wrote "In the summer of 1928 approximately two million trees were freshly attacked on 20,000 acres in the southern part of the area." (This meant that there was an average of 100 newly infested trees per acre). Later, Struble and Johnson (1955) said "Infestations in pure stands of lodgepole pine in the Rocky Mountains, Cascade Range, and Sierra Nevada, often develop rapidly and maintain outbreak status until every tree more than 3 inches in diameter is killed." More recently, Cole (1963) speculated that "Infestations in pure stands of lodgepole pine can develop rapidly and either maintain epidemic status until the majority or all of the trees 3-5 inches in diameter are killed or subside rather quickly." It is, indeed, interesting to note that once these statements were made, irrespective of statistical support, they soon became fact, each supporting the other, until finally they eventually wove their way into administrative confidence and became a factor in the making of control decisions. Quite frankly, other than the surveys conducted by Evenden and Gibson (1940) during and following an outbreak on the Beaverhead National Forest, where they found 36 percent of the stand (over 3 inches d.b.h.)[1/] killed, there was no factual evidence, cursory or otherwise, that effectively portrayed the residual stand structure following a mountain pine beetle outbreak. Certainly, there was no stand data for the lodgepole forests of the Intermountain Region, at least not until 1967.

In 1967, 11 stands depleted by the mountain pine beetle in the Teton Wilderness, Teton National Forest, were cruised by the variable plot method, and the results were incorporated into the annual biological evaluation report.[2/] The residual stand structure data partly

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1/ The methods used to obtain this data were omitted from the article.

2/ Forest insect conditions on the Teton National Forest and in the Grand Teton National Park, 1967, 6pp. typed (copies available upon request).

paralleled the stand losses surveyed by Evenden and Gibson (1940); i.e., the larger trees suffered the heaviest losses, but the overall mortality was considerably less. In the 11 Teton stands, tree losses above 7 inches d.b.h. ranged from under 10 percent to 34 percent of the total stand. These figures, surprisingly, were considerably below expectations.

Since 1967, stand structure data, depicting lodgepole stands prior to, during, and following mountain pine beetle infestations, have been taken as a matter of routine and become an integral part of evaluation reports.1/ This information has not only been of value to the land manager by enabling him to consider management alternatives, but it has also aided the entomologist in forecasting population trends.

One factor that became evident from this cruise information was the variability of lodgepole pine stands. No two stands are the same and, most important, there is little similarity in stand structure following a mountain pine beetle outbreak. Initial stand structure, species composition, elevation (Amman, Baker and Stipe 1971); habitat type (Roe and Amman 1969) extensiveness of the stand(s) and the impetus of the infestation are some of the most obvious factors that influence final mortality. In essence, there is no such thing as an average stand structure before, during, or following a mountain pine beetle outbreak. Losses also vary. Information collected to date, excluding the 1967 Teton cruise, indicates that in the aftermath of an infestation, anywhere from 10 to 45 percent of the stand 5 inches d.b.h. and larger is killed. The life of an infestation2/ is 7 to 8 years, with peak killing occurring the fifth or sixth year.

OBJECTIVE

The objective of this report is threefold: First, to describe and illustrate stand loss caused by the mountain pine beetle in one small area; secondly, to briefly review past and present survey information; and finally, to document the methods by which stand structure data is collected, processed, and analyzed. A discussion of this type would probably be highly effective and certainly more convenient if it was

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1/ In addition to stand structure cruises, supplemental data on both impact and trend are being compiled. Trend data, as reflected by annual stand attrition over the life of an infestation, is now being collected from two widely separated infestations--one in Yellowstone National Park and the other on the Bridger National Forest. Small format color aerial photograph (35mm) is also being used to measure tree losses over large areas. The results of all of these studies are forthcoming.

2/ Infestation life is based on the period during which "noticeable" tree killing occurs. The lower threshold of noticeable tree killing which occurs at the "beginning" and at the "end" of an outbreak is arbitrarily established at 0.5 trees per acre.

centered on an "average" stand or "average" tree killing. If such a stand existed, it would, of course, be measured, the data compiled and analyzed, and the results distributed as guidelines. Lacking this information, then, and with the original intent of effectively describing the beetle's impact by bringing it into some meaningful perspective, it was decided to do the next best thing, and that was to document not an average situation, but an extreme one.

The next step was to find a stand which represented an extreme condition. Candidate areas were on the Swan Valley District of the Targhee National Forest, Bridger Division of the Bridger National Forest; BLM lands near the headwaters of the Hoback River; and near Arizona Lake, in Teton National Park and Teton National Forest. The Arizona Lake infestation was selected (Figure 1).

THE AREA

The lodgepole stands in the Arizona Lake area have been under attack for several years. The infestation started during the early 60's, reached its peak around 1966, and has been on the decline since. Suppression by spraying standing infested trees with a toxic chemical was undertaken in 1964 and again in 1966 and 1967. These efforts may have extended the life of the infestation somewhat but had no effect in reducing the overall mortality. (Amman and Baker 1972).

The affected stand, 320 acres in size, is predominately lodgepole pine (82%) intermixed with subalpine fir (11%), Douglas-fir (5%), and Engelmann spruce (2%). The area has a mean elevation of 7,000 feet and runs from Arizona Lake west to the Teton-Yellowstone Park Highway.

METHODS

The general area was first photographed from the air and on the ground using color and color infrared film (Figures 2, 4 and 7). The cruise area was then delineated on a resource aerial photograph and located on the ground. Thirty-two variable plots (BAF 10) were established in a systematic grid pattern at 10-chain intervals throughout the area (Figures 2 and 3). All lodgepole pine, living and dead, and other live tree species above 5 inches d.b.h.[1/] were counted and measured. Data were recorded on standard field forms and later transferred to a key-punch unit for compilation and analysis by automatic data processing (Table 1).

1/ Measurements were taken by 2-inch diameter classes. For example, the 10-inch class ranges from 9.0 to 10.9 inches.

RESULTS

The first impression one gets from the aerial photographs does not appear to be consistent with the ground data. Neither are the views from within the stand (Figure 7) or from outside the stand looking in (Figure 6). Somewhat surprising, the data indicate that 45 percent of host-type and only 37 percent of the total stand was killed by the mountain pine beetle (Table 2). In terms of wood volume (8 inches d.b.h. and above), 52 percent of host-type and 45 percent of the total stand was lost (Table 3). The stand now contains 5,620 board feet of lodgepole and 1,880 board feet of associated species, for a total live volume of 7,500 board feet per acre. Approximately 64 lodgepole pine per acre are dead, with over 55 percent of the total mortality occurring in the 8- and 10-inch size classes. Mortality to pole size trees (5.0 inches and below) was negligible. Although the larger trees (12.9 inches d.b.h. and larger) occupy only 10 percent of the stand (5 inches d.b.h. and larger), they suffered the heaviest losses, meaning that mortality of the various diameter classes is inversely proportional to their occurrence in the stand. Therefore, there is reason to suspect that the intermediate diameter classes were primarily responsible for carrying the brunt of the infestation during its life span.

DISCUSSION

This is an account of a lodgepole pine stand in the aftermath of a mountain pine beetle outbreak. It is an extreme example. The stand structure has been significantly changed from what it was 10 years ago. Does this mean that management objectives for this and other areas depleted by the mountain pine beetle have to change accordingly? In a National Park where recreation and the preservation of a pristine environment are paramount objectives, probably not--at least not drastically (increased fire hazard and the disposition of dead trees in recreation sites will be of great concern). But what about the plans of other land managing agencies who adhere to the principles of multiple use and have experienced less or similar tree losses? Certainly their management alternatives would need reexamination and their objectives possibly redefined. Areas where timber values were relatively high are now low; where fire hazard was low, it is now high; where the cost of road and trail maintenance was once feasible, it is now expensive; and where choice of fully stocked recreation sites were once abundant, they are less plentiful. These, then, are only a few of the more tangible changes that now confront the land manager. Before he can adjust and make the necessary revisions, he must not only know the intensity and extent of tree losses, but, if possible, the full impact of the infestation; that is, the total or complete change in the environment brought on by the depleted stands. Hopefully this report will provide the land manager a more realistic view of what to expect from such infestations and thus assist him in his management actions.

SUMMARY

1. The Arizona Lake infestation is only one small example of the impact of the mountain pine beetle on a lodgepole pine stand in the Intermountain Region. Certainly there are other stands which suffered similar or even greater tree losses, but they, too, in the light of present knowledge, would also be considered extreme. In the Arizona Lake infestation, in host type, 45 percent of the trees (5.0 inches d.b.h. and larger) were lost. In other stands and during other times, tree losses range between 10 and 45 percent of the stand.

2. The majority (55%) of the dead trees are in the 7.0-10.9-inch size class range. It is suspected that these intermediate size trees played a significant and indispensable role in maintaining the infestation.

3. A mountain pine beetle outbreak in lodgepole pine appears far worse than it really is. Meaningful loss estimates can only be obtained from systematic, factual cruise data.

4. Cataclysmic losses of lodgepole pine previously ascribed to the mountain pine beetle in other areas have never occurred in the Intermountain Region. In fact, it is questionable whether some of those extreme losses ever occurred. As an example, Hopping and Mathers (1945) cited a 20,000-acre area containing an average of 100 trees per acre infested in 1 year. By comparison, only a combined total of 64 trees per acre were killed in the Arizona Creek infestation, but these losses occurred over a period of 7 to 8 years. The highest annual infestation rate ever documented in this Region was 27 trees per acre.[1/]

5. Now that most of the infestation has subsided, resource managers and others who have inherited vast areas of depleted forests and are responsible for managing them must accept the losses and revise their management goals accordingly. Before doing so, however, they will have to know both the intensity and extent of these losses.

1/ Parker, Douglas L. 1971. Mountain Pine Beetle Trend and Impact Study in Yellowstone National Park. U.S. Forest Service. Region 4. Mimeo. 4pp. (This well-stocked stand, measured annually over the life of the infestation, lost 55 trees per acre during a 7-year period.)

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APPENDIX

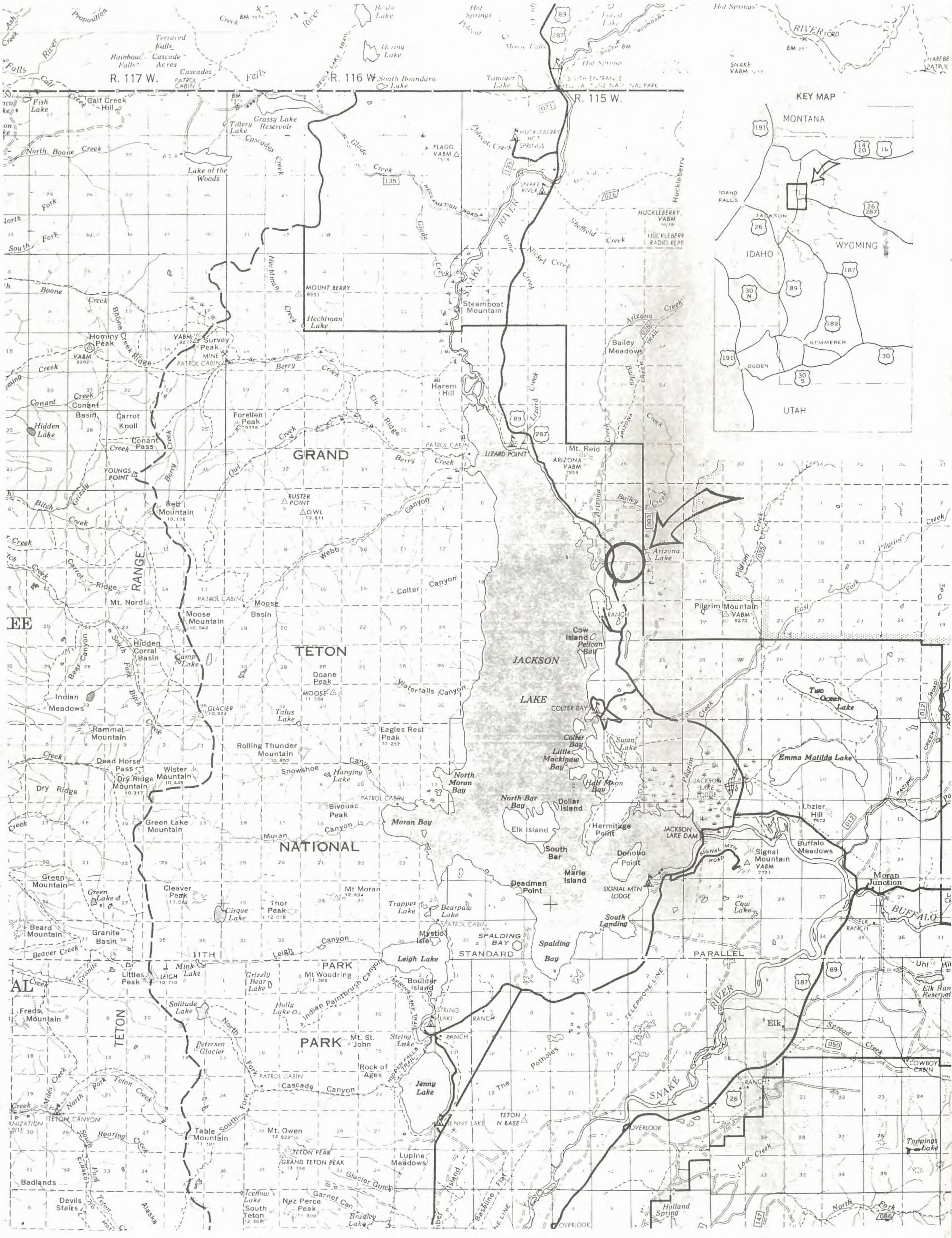

Figure 1. Portion of Grand Teton National Park showing cruise area.

Figure 2. Aerial oblique view of the Arizona Lake infestation, Grand Teton National Park and Teton National Forest. Jackson Lake in background.

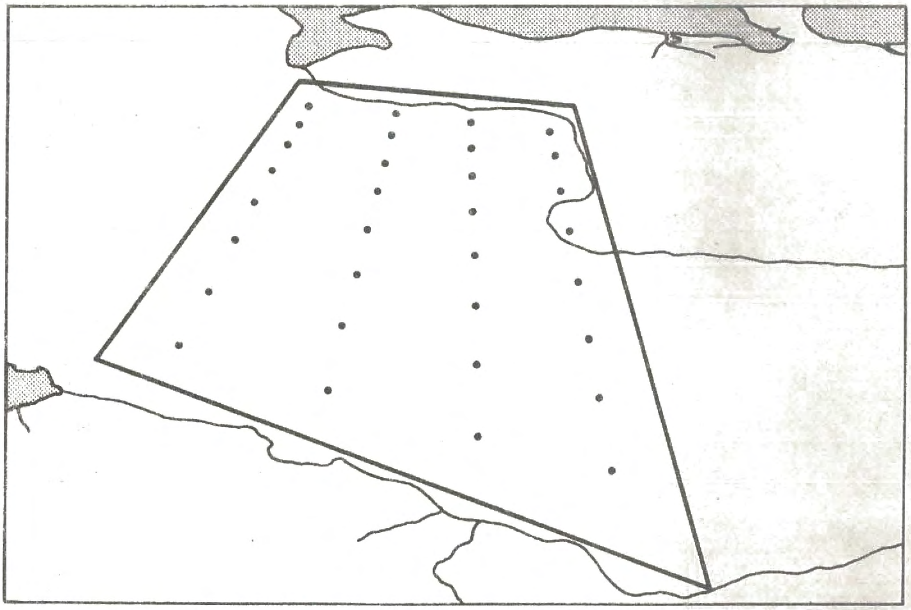

Figure 3. Drawing showing cruise area boundaries and general plot locations. Thirty-two variable plots (BAF 10) were spaced at 10-chain intervals.

Figure 4. Ektachrome infrared aerial photograph of Arizona Lake infestation. Snags (dead trees) are turquoise in color, live green trees appear red, and red tops (faders) show yellow.

Figure 5. Aerial oblique stereogram of Arizona Lake infestation. Note red tops (faders) in background.

Figure 6. Ground view of Arizona Lake infestation looking southwest across meadow. Small timber island is on right. North section of Grand Teton Range (across Jackson Lake) is in background.

Figure 7. Stereogram taken inside infestation (cruise area) showing lodgepole pine trees killed by the mountain pine beetle.

S U R V E Y
11/22/71

POPULATION STAND TABLE
ARIZONA LAKE OCT 7 1971
HOST SPECIES IS LODGEPOLE PINE

THE INSECT NAME IS MOUNTAIN PINE BEETLE

THE METHOD OF SAMPLING WAS VARIABLE THE FIGURES IN THIS TABLE ARE BASED ON A SAMPLE OF 32 PLOTS, AND

REPRESENT AN AREA OF 0ACRES.

BAF WAS 10

THIS TABLE ONLY INCLUDES HOST TREES

N U M B E R S O F T R E E S

P E R A C R E

DBH	LIVE	NEW	OLD	SNAG	TOT. DEAD	PERCT. DEAD	TOTAL	PERCENTILE
5.0- 6.9	15.916	0	0	6.366	6.366	28.571	22.282	15.676
7.0- 8.9	21.486	0	0	17.905	17.905	45.455	39.391	27.713
9.0- 10.9	22.345	.573	0	17.189	17.762	44.286	40.107	28.217
11.0- 12.9	12.335	.398	0	9.947	10.345	45.614	22.680	15.956
13.0- 14.9	5.554	1.169	0	6.139	7.308	56.818	12.862	9.049
15.0- 16.9	.671	0	0	2.910	2.910	81.250	3.581	2.519
17.0- 18.9	0	0	0	1.238	1.238	100.000	1.238	.871
TOTAL	78.31	2.14	0	61.69	63.83	44.91	142.14	100.00
PERCENT	55.09	1.51	0	43.40	44.91			

BASAL AREA PER ACRE FOR HOST TREES

LIVE	NEW	OLD	SNAG	TOT. DEAD	TOTAL
39.3750	1.8750	0	37.5000	39.3750	78.7500

Table 1. Computer "print out" of host type statistical summary, Arizona Lake Cruise.

Table 2. Stand Structure Analysis (Trees Per Acre) of Lodgepole Pine Stand Following a Mountain Pine Beetle Outbreak, Grand Teton National Park and Teton National Forest, 1971.

Area		Diam. Class	Trees Per Acre							
			Lodgepole Pine Live		Lodgepole Pine Dead		Other Spp.2/ Live		Total All Spp.	
		(In.)	(No.)	(%)1/	(No.)	(%)1/	(No.)	(%)1/	(No.)	(%)1/
Arizona Lake		6	15.9	9.2	6.4	3.7	12.7	7.3	35.0	20.2
Basal Area/Acre		8	21.5	12.3	17.9	10.3	11.6	6.7	51.0	29.3
Live Lpp.	39.4	10	22.3	12.8	17.8	10.2	1.1	0.6	41.2	23.6
Dead Lpp.	39.4									
Other Spp.2/	14.7	12	12.3	7.1	10.3	5.9	2.0	1.2	24.6	14.2
Total	93.5	14	5.6	3.2	7.3	4.2	1.5	0.9	14.4	8.3
		16	0.7	0.4	2.9	1.7	0.4	0.3	4.0	2.4
SE%3/	8.1	>16	0	0.0	1.2	0.7	2.1	1.3	3.3	2.0
			78.3	45.0	63.8	36.7	31.4	18.3	174.5	100.0

1/ Percent of Total Stand

2/ Subalpine fir, Douglas-fir, Engelmann Spruce

3/ One Standard Deviation

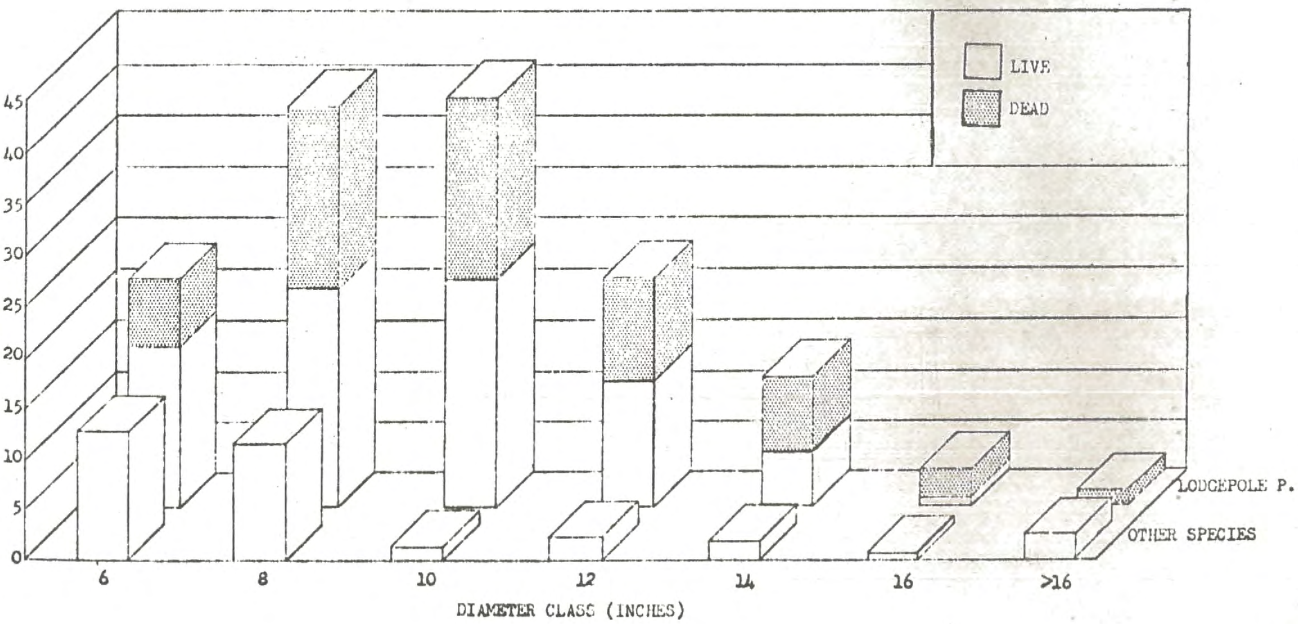

Table 3. Stand Structure Analysis (Volume Per Acre) of Lodgepole Pine Stand Following a Mountain Pine Beetle Outbreak, Grand Teton National Park and Teton National Forest, 1971.

Area	Diam. Class	Volume Per Acre Scribner							
		Lodgepole Pine				Other Spp. 2/		Total	
		Live		Dead		Live		All Spp.	
	(In.)	(Bd.Ft.)	(%)	(Bd.Ft.)	(%)	(Bd.Ft.)	(%)	(Bd.Ft.)	(%)
Arizona Lake	8 1/	784	5.8	623	4.7	406	3.0	1,813	13.5
	10	1,985	14.7	1,584	11.6	98	0.7	3,667	27.0
	12	1,611	11.8	1,349	9.9	262	1.9	3,222	23.6
	14	1,062	7.8	1,409	10.3	290	2.1	2,761	20.2
	16	178	1.3	740	5.4	102	0.7	1,020	7.4
	>16	0	0.0	413	3.0	722	5.3	1,135	8.3
		5,620	41.4	6,118	44.9	1,880	13.7	13,618	100.0

1/ Data were originally taken by 2-inch diameter classes. The range of the 8-inch diameter class is 7.0 to 8.9 inches. In this analysis, only trees greater than 8.0 inches are included.

2/ Subalpine fir, Douglas-fir, and Engelmann spruce.